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# आवृत्ति काउंटरों ( 1 मीगा हर्ट्ज आवृत्ति तक ) के गुणधर्मों की अभिव्यक्ति

*Indian Standard*

# EXPRESSION OF PROPERTIES OF FREQUENCY COUNTERS ( UP TO A FREQUENCY OF 1 GHz )

UDC 621·317·76

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**BUREAU OF INDIAN STANDARDS**
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NEW DELHI 110002

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**Price Group 4**

Electrical and Electronic Test and Measuring Instruments, Systems and Accessories Sectional Committee, LTD 21

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Electrical and Electronic Test and Measuring Instruments, Systems and Accessories Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

The object of this standard is to lay down uniform methods of expression of the properties of frequency counters specifically:

a) to define terminoloy and catalogue data related to these types of instruments; and

b) to specify methods for testing these types of instruments in order to verify compliance with properties claimed or specified by the manufacturer.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it should be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values ( *revised* )'.

# *Indian Standard*

# EXPRESSION OF PROPERTIES OF FREQUENCY COUNTERS ( UP TO A FREQUENCY OF 1 GHz )

## 1 SCOPE

**1.1** This standard is applicable to instruments known as frequency counters to measure time related properties of a repetitive signal available in electrical form, hearafter called 'input signal', at its inputs.

**1.2** As the fundamental property these instruments measure frequency of a signal by direct or prescaled counting process and display the measured value in digital form on their displays.

**1.3** In addition these instruments may have facilities to measure time period, time interval, ratio of two frequencies and event counting.

NOTE — This standard is applicable to frequency counters up to a frequency of 1 GHz and does not apply to frequency counters which use the technique of reciprocal counting or super-heterodyning principle.

## 2 REFERENCE

The following Indian Standard is a necessary adjunct to this standard:

IS 9176 : 1979 Methods for specifying the functional performance of the electronic measuring equipment.

## 3 TERMINOLOGY

For the purpose of this standard definitions given below shall apply. The characteristics which are defined below consist of three types:

a) terms related to types of frequency counters;
b) terms related to input characteristics; and
c) terms related to operating modes of the instruments.

### 3.1 Term Related to Types of Frequency Counters

#### 3.1.1 *Frequency Counter*

An instrument that has the basic capability of measuring frequency of a signal. The instrument in addition may have any of the capabilities or combination thereof to measure time period, rpm, totalize and time interval of two events.

#### 3.1.2 *Universal Counter*

An instrument that has the basic capability of measuring frequency of a signal as well as capabilities to measure time period, time interval, ratio between two frequencies and totalize ( event counting ).

NOTE — For both the above definitions the technique of direct counting or prescaled counting may be used for a part or full frequency range. The manufacturer shall specify 'direct counter' or 'prescaled counter' for the respective part of the range.

### 3.2 Terms Related to Input Characteristics

#### 3.2.1 *Sensitivity*

This is the lowest amplitude of the sinusoidal signal at the input point, expressed as rms in units of volts which the instrument is capable of measurement.

#### 3.2.2 *Frequency Range*

This is the range of frequency over which the instrument is capable of measuring and displaying the measured value satisfying sensitivity condition.

#### 3.2.3 *AC Coupling*

This is the mode where the AC components alone of the input signal are allowed to be processed for measurements and the DC component, if any, is blocked within the instrument.

#### 3.2.4 *DC Coupling*

This is the mode where DC component, if any, is also allowed to be processed along with AC components of the input signal.

#### 3.2.5 *Attenuation*

This is the amount by which the input signal is attenuated within the instrument for further processing. This is expressed as a ratio or in dB.

#### 3.2.6 *Trigger Level*

This is the DC level at which the input signal is recognized within the instrument for measurement, expressed in units of DC volts.

NOTE — The DC level range over which tigger level is settable shall be specified.

### 3.2.7 *Auto Triggering*

This is the mode where the input signal is automatically recongized within the instrument irrespective of the presence of DC components in the signal.

### 3.2.8 *Dynamic Range*

This is the maximum allowable peak to peak amplitude of the input signal expressed in units of volts when centred at the middle of the trigger level range.

### 3.2.9 *Trigger Edge*

This is the edge of the input signal at which the signal is recognized within the instrument.

### 3.2.10 *Trigger Slope*

This is the minimum slope of the rising or falling edge of the input signal at trigger point above which the input signal is unambiguously recognized within the instrument. This is expressed in units of volts/units of time.

NOTE — If trigger slopes are different for rising and falling edges, it shall be specified by the manufacturer separately.

### 3.2.11 *Input Impedance*

This is the effective impedance at the input point of the instrument offered to the input signal under operating conditions.

### 3.2.12 *Input Protection*

This is the maximum amplitude of the input signal including DC and AC peak that the instrument can withstand without damage.

NOTE — Protection levels may vary for different attenuator positions, coupling used and also over frequency range. The manufacturer shall specify separately for such conditions.

## 3.3 TERMS RELATED TO OPERATING MODE CHARACTERISTICS

### 3.3.1 *Range*

This is the range of the parameter that the instrument measures and displays. The manufacturer shall specify ranges separately for frequency, time period, time interval, frequency ratio and totalize.

NOTES

1 a) Frequency range is specified in units of Hz.
   b) Period range is specified in units of Hz or time.
   c) Time interval range is specified in units of time.
   d) Ratio range is specified in units of Hz, for both the input signals, and
   e) Totalize ( event counting ) is specified in units of Hz.

2 In totalized mode the range is from the minimum to maximum frequency at which the events may occur.

### 3.3.2 *Gate Time*

This is the 'duration' during which is in frequency measurement made the input signal is allowed to be counted.

### 3.3.3 *Number of Cycles Averaged*

This is the number of input cycles accepted by the instrument in time period or time interval mode for one measurement.

### 3.3.4 *Resolution*

This is the minimum deviation of the input signal which the instrument is capable of displaying. It is expressed in terms of the units of the range set.

### 3.3.5 *LSD Displayed*

This is the place value of the right most or least significant digit of the displayed value with respect to the range set for best resolution. It is expressed in the units of the range set ( *Example* : n sec for time interval ).

### 3.3.6 *Time Base*

This is the reference clock to generate timing information inside the instrument.

#### 3.3.6.1 *Internal time base*

This is the reference clock generator already residing in the instrument.

#### 3.3.6.2 *External time base*

This is the reference clock generator external to the instrument that can be input to the specified input point to generate timing information.

#### 3.3.6.3 *Time base ageing rate*

This is the permanent fractional frequency change in the time base due to laps of time. This is expressed as f/f over a period time where f is the frequency of the time base ( *Example* : $3 \times 10^{-7}$/month ).

#### 3.3.6.4 *Time base temperature stability*

This is the fractional shift in time base frequency due to variation in ambient temperature. This is expressed as f/f over a temperature span, where f is the time base frequency. ( *Example* : $4 \times 10^{-7}$ over 0°C to 45°C ).

**3.3.6.5** *Time base short term stability*

This is the fractional shift in time base frequency over a very short period of time. This is expressed as f/f over a short span of time typically 1 second ( *Example*: $4 \times 10^{-7}$/ sec )

**3.3.7** *Accuracy*

This is the closeness of a measured value with respect to the true value expressed by the maximum amount of deviation possible from the true value.

**3.3.7.1** *Frequency accuracy*

This is the maximum deviation of the measured frequency possible from its true value and expressed in number of counts.

NOTES

1 This is the cumulative effect due to time base change ( due to ageing, temperature variation and short term line voltage variation ) and quantization error.

2 Frequency Accuracy = ±1 count ± Time base error.

**3.3.7.2** *Time period accuracy*

This is the maximum deviation of the measured time period possible from its true value are expressed in number of counts.

NOTES

1 This is the cumulative effect due to time base change, quantization error and error due to shirt in trigger point, caused due to noise in the input signal.

2 Time period accuracy = ± 1 Count ± Time base error ± trigger error/N; where N is the number of input cycles.

**3.3.7.3** *Time interval accuracy*

This is the maximum deviation of the measured time interval possible from the true value. It is expressed in number of counts.

NOTES

1 This is the cumulative effect due to time base change, trigger error, and error due to difference in channel propagation delay.

2 Time interval accuracy = ± LSD ± Time Base Accuracy ± Trigger error/$\sqrt{N}$ + interchannel propagation delay.

## 4 GENERAL TEST REQUIREMENTS

### 4.0 General

General test conditions and procedures shall be according to IS 9176-1979 and the following data is based on it.

### 4.1 Statement of Limits of Errors

**4.1.1** Limits of operating error (which apply under rated operating condition ) shall be stated.

**4.1.2** Limits of intrinsic error ( which apply under reference conditions ) may be stated. In the absence of a statement, they are considered to be equal to the limits of the operating error.

**4.1.3** Limits of influence error may be stated. It is particularly useful to state these limits when one influence quantity on influencing characteristic causes an important part of the operating error. It may also be on interest to state that certain environmental conditions do not contribute to the operating error.

**4.1.4** Limits of variation may be stated when this standard explicitly permits it.

**4.1.5** Limits of stability error ( drift ) may be stated by the manufacturer either for the maximum time interval within which limits of operating error are not exceeded or the limits of this error together with the relevant time interval. The time intervals shall conform to this standard or be chosen in accordance with IS 9176-1979.

### 4.2 Performance to be Verified and Checked

The test described in this standard are to be performed in order to verify compliance with the manufacturer's stated date. Test procedures are given in **5**.

### 4.3 Conditions for Test Location

Unless otherwise specified in this standard, the following conditions shall be maintained in the test location:

a) Temperature within the range of 15 to 35°C

b) Relative humidity within the range of 45 to 75 percent

c) Air pressure within the range of 70 to 106 kPa, and

d) The frequency counters shall be operated with the rated values of supply voltage and frequency.

NOTE — The values indicated above should bot be confused with those indicated in **4.9** for reference conditions and test conditions.

### 4.4 Type Test

**4.4.1** The test specified in the following clauses are type tests applicable to frequency counters ready for use, that is, with covers and accessories fitted, if necessary.

**4.4.2** When carrying out type test, each frequency counter tested shall be subjected to each of the tests laid down in this standard, as applicable, and as agreed between the manufacturer and the user.

**4.4.3** In general, measurements for verification shall be carried out with instruments which do not appreciably ( or only calculably ) affect the values to be measured. In principle, the errors in measurements made with these instruments should be negligible in comparison with the errors to be determined.

**4.4.4** When the error of the instrument is not negligible, the following rule shall apply. If a frequency counter is claimed to have a limit error of ± e percent, for a given performance characteristic and the manufacturer uses for its checking an apparatus resulting in an error of measurement of ± n percent, the error being checked shall remain between the limits ± ( e − n ) percent; likewise if a user checks the same frequency counter using another apparatus resulting in an error of measurement of ± m percent, he is not entitled to reject frequency counter if its apparant error exceeds the limits of ± ( e + m ) percent.

### 4.5 General Conditions for Test Purposes

Tests are carried out under the conditions given in **4.6** and **4.7** below and, if agreed between manufacturer and user, under that combinations of conditions which may be expected to result in the maximum operation errors.

### 4.6 Standard Values and Ranges of Influence Quantities

**4.6.1** The reference values or ranges, the rated ranges of use and the limit ranges of operation, storage and transport for all influence quantities shall be stated and shall be selected by the manufacturer from one of the usage groups, as specified in IS 9176-1979. Any exceptions to the values given, there shall be explicitly and clearly stated by the manufacturer with an indication that they are exceptions.

**4.6.2** The frequency counter may correspond to one group of rated ranges of use for environmental conditions and to another group for mains supply conditions, but this must be clearly stated by the manufacturer.

### 4.7 Preparation for Tests

Before tests are performed, the following shall apply.

**4.7.1** Adjustments, if any, shall have been performed according to the manufacturer's instructions.

**4.7.2** Before being switched on, the frequency counter shall be in equillibrium with the temperature and humidity of the ambient air.

**4.7.3** The frequency counter shall be operated at the rated value of supply voltage for a period equal to the warm-up time as indicated by the manufacturer.

In the absence of any indication, this period shall be one hour.

**4.7.4** After the warm-up time, further adjustment may be made by means of the appropriate controls in accordance with the manufacturer's instructions.

### 4.8 Particular Conditions

The controls shall be set and signals applied to the input, as indicated at the head of each of the applicable clauses.

When no indication is given for a control setting, it may be set to any suitable value. Unless otherwise specified, no signal is applied.

### 4.9 Reference Conditions

For the purpose of tests on frequency counters, a selection of influence quantities and influences characteristics with their reference values and/or ranges is given in Table 1.

## 5 TEST PROCEDURES

**5.0** In each of the following tests the results shall fall within the range of the manufacturer's stated.

### 5.1 Display Frequency

Set a stable display of frequency for a test signal in the frequency counter from a synthesized signal generator or some other external means. The deviation of the display frequency on the frequency counter is the frequency error.

Check for the entire range as specified by the manufacturer.

If variable gate time control is provided in the frequency counter, for each gate time setting, check for the entire range as specified by the manufacturer.

NOTE — If more than one input channel is available in the frequency counter, the above test procedure is to be followed for each channel.

### 5.2 Sensitivity

Set the frequency counter, at the minimum of the range and for 'zero' level triggering. Apply the test signal at specified minimum frequency from a synthesized signal

## Table 1 Reference Conditions

( *Clause* 4.9 )

| Influence Quantities or Influence Characteristics | Reference Conditions | | Tolerance on Reference Value Permitted for Testing Purposes |
|---|---|---|---|
| | When the Reference Conditions are indicated | In the Absence of Indication | |
| ( 1 ) | ( 2 ) | ( 3 ) | ( 4 ) |
| Ambient temperature | 20°C, 23°C<br>25°C, 27°C | 25°C | ±2°C |
| Ambient air relative humidity | 45 to 75 percent | | |
| Air pressure (altitude) | 101·3 kPa | | |
| Supply voltage | Rated value | | ± 1 percent for dc and ac rms<br>± 2 percent for ac peak |
| Frequency of ac supply | Rated value | | ± 1 percent |
| Waveform of ac supply voltage | Sinusoidal | | Difference between 2 times the rms value and peak value to within ± 1 percent |
| Ripple content of dc voltage | Value given by the manufacturer | Negligible | |

generator and set its amplitude for a stable display in the frequency counter. Reduce the amplitude of the test signal gradually and read the minimum amplitude below which the frequency counter display gives inaccurate frequency reading. The test signal amplitude at this point is the sensitivity of the frequency counter at the set frequency.

Perform the above throughout the frequency range as specified by the manufacturer to check sensitivity specifications.

### 5.3 Coupling

Set the trigger level in the frequency counter for a particular DC value, in DC coupling mode. Apply a test signal with no DC component from a signal generator with a peak to peak value less than double the set trigger level. Note that there will be no display of frequency. Add a DC level approximately equal to set trigger level to the test signal. There will be accurate display of frequency of the test signal.

Set the frequency counter in AC coupling mode, there will again be no display of frequency in the frequency counter.

Set trigger level to zero level triggering. There will be display of the test signal frequency.

### 5.4 Attenuation

Set the frequency counter in AC coupling mode and set for zero level triggering. Set no attenuation in the frequency counter. Apply a test signal from a synthesized signal generator at a frequency which is within the range specified. From very low level gradually increase the peak to peak amplitude of the test signal. Stop at the point where triggering is just achieved and the frequency counter displays the frequency within accuracy. Note this peak to peak amplitude of the test signal, say $V_1$. Set the desired attenuation in the frequency counter, say $a_1$. Set the test signal amplitude to $a_1 v_1$ and check if the frequency counter is triggering and giving the correct display of frequency. For all other attenuation settings apply the above method to verify attenuation function.

### 5.5 Trigger Slope

Set the frequency counter in DC coupling mode and for zero level triggering.

Apply test signal of peak to peak value, say V 2 at the lowest frequency from a signal generator having facility to add DC level with the signal. Adjust DC level to negative DC in the signal generator such that negative DC is more than peak to peak of the test signal. Gradually increase DC level towards positive. Stop at the point where triggering is achieved and correct frequency is displayed. Read negative DC value.

Calculate slope as :

$$V_1 = \frac{V_1}{2} \sin 0_1, \quad \text{Therefore, } 0_1 = \sin^{-1} \frac{2V_1}{V_2} \quad \ldots(1)$$

$$(\, 0 = 2 \text{ ft}\, )$$

$$\text{Slope} = \frac{dv}{dt}(\, t = t_1\, ) = \frac{V_2}{2} 2\, \pi\, f \cos 0_1 \qquad \ldots(2)$$

from (1) and (2) calculate slope. Compare this value with the one specified by the manufacturer.

NOTE — If more number of frequency channels are available, each channel shall be tested as per **5.5** as will be applicable.

### 5.6 Dynamic Range

**5.6.1** *When Level Triggering Facility is Available*:

Set the trigger level Vtrig set at

$$\frac{V\,\text{trig}_{\max} + V\,\text{trig}_{\min}}{2}$$

in the frequency counter. Set DC coupling made with no attenuation. Apply a test signal at the frequency where this parameter is to be checked. Add DC component = $V$ trig set to the test signal. Set amplitude of the test signal equal to the level specified by the manufacturer for dynamic range. Check if the frequency counter is correctly reading the test signal frequency.

Check in the above manner at other frequency points as specified by the manufacturer.

**5.6.2** *When Only Auto Triggering is Available*

Apply a test signal from a synthesized signal generator at a frequency at which dynamic range is desired to be checked. Set the amplitude of the test signal equal to the maximum level specified by the manufacturer at the set frequency and check if the counter is measuring correctly the frequency.

Repeat the above process at all the frequencies where the specification is desired to be checked.

### 5.7 Trigger Level

Set the trigger level at minimum of its range with no attenuation in AC coupling mode. Apply a test signal of relatively higher frequency from a signal generator.

Increase the amplitude of the test signal gradually. Stop at the point where triggering is achieved and the counter displays correct frequency. Measure the peak to peak amplitude of the test signal, say, $V_1$.

The trigger level shall be $\frac{V_1}{2}$

Repeat the above test procedure by setting the maximum trigger level as specified for the instrument.

Compare the measured values with the ones specified by the mannfacturer.

### 5.8 Period Range

Set the frequency counter for zero level triggering and in AC coupling mode. Apply the test signal from a synthesized signal generator at a frequency which is the lowest of the specified range and with an amplitude equal to the sensitivity value specified for the set frequency.

Note the displayed value and compare if this is within specified accuracy limits.

Repeat the above test at the maximum of the specified range.

Repeat the above test for different setting of number of input cycles.

### 5.9 The Interval Range

Set the frequency counter in DC coupling mode. Use a pulse generator having facility of pulse width variation and a second output for complimentary wave form but with zero phase shift.

Adjust the width of the pulse train to a period equal to the minimum time interval specified by the manufacturer with the help of a standard frequency counter.

Apply direct output of pulse generator to first channel of the frequency counter and the complimentary output in the second channel. Set the trigger levels for both the channel set approximately half of the pulse amplitude level and set both channels for rising edge triggering.

Read the value displayed in the frequency counter under test, say $T_2$. Calculate from the manufacturer's specifications and accuracy figures the true value of time period and compare with $T_2$. Repeat the above for width of the pulse train equal to the maximum of the time interval range specified for the frequency counter under test.

### 5.10 Frequency Ratio

Apply two different test signals from two different signal generators to the inputs of the frequency counter. Check the ratios at minimum and maximum of specified frequency ranges for these two channels.

## 6 STABILITY ERRORS

### 6.1 Stability Errors to be Tested

**6.1.1** The stability errors for frequency counters are divided into short-term drift, due to ambient temperature variation and long term drift of the time base frequency.

**6.1.2** Tests of on stability errors on time base frequency shall be performed when limits of such errors have been separately stated by the manufacturer, that is, if not included in the operating error.

**6.1.3** *Schedule of Tests*

**6.1.3.1** The stability errors of short term and long term frequency drifts shall be determined according to Table 2.

**6.1.3.2** The stability error due temperature variation shall be determined according to Table 3.

**6.1.4** *Duration of Tests*

Test duration for the determination of short term and long term drift shall be equal to the related time interval stated by the manufacturer and shall be chosen from the following values:

| | | | |
|---|---|---|---|
| 1 hour | 10 days | 3 months | 1 year |
| 3 hour | 30 days | 6 months | |
| 7 hours | | | |
| 24 hour | | | |

However, they shall not be less than the following:

a) 7 hours for short term frequency drift, and

6) 6 months for long term frequency drift unless other will specified by the manufacturer.

**6.1.5** *Condition of Test*

**6.1.5.1** Test on stability errors shall be carried out under reference conditions.

**6.1.5.2** During short term drift tests no calibration adjustments are permitted. During tests on long term drift, which may contain operative and in operative intervals calibration adjustments that are part of the normal operating procedure are permitted; however, no adjustment by external means or of only internally accessible parts are permitted.

**Table 2 Schedule for the Determination of Stability Errors**

( *Clause* 6.1.3.1 )

| Stability Error to be Tested | Total Time of Test | No. of Observation Period | Length of One Observation Period | Time Interval 16 between two Successive Readings | Value to be Noted |
|---|---|---|---|---|---|
| Drift ( short term or long term as applicable ) | 1 h<br>3 h<br>7 h<br>7 h | 12*<br>36<br>60<br>60 | 1 min | Approx. 5 sec ( correspondings observation period ) | Average value of each observations period and the difference between the max and the min of these average values. |

*Equally distributed over the total test time.

**Table 3 Schedule for the Determination of Variation Due to Temperature**

( *Clause* 6.1.3.2 )

| Stability Error to be Tested | Total Span Temp | Length of One Observation Temp | Value to be Noted |
|---|---|---|---|
| Frequency Drift | 15 to 50°C | 50°C | Average of value calculated over 100 readings and max deviation of any indicated value from that average value. |

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